Energy reconstruction

Part II - High Energy

September 2000
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Shower leakage corrections

SEVERAL OPTIONS:

- Shower profile fitting

- Shower profile and covariance matrix

- Leakage estimate with last layer

SHOWER MODEL:

Longitudinal profile described by gamma distribution with 2 fluctuating parameters

$$f_L(z) = \frac{1}{\lambda}(z/\lambda)^{\alpha-1}e^{-z/\lambda}$$

Energy in i-th layer:

$$E_i = E_0[P(\alpha, z_i/\lambda) - P(\alpha, z_{i-1}/\lambda)]$$

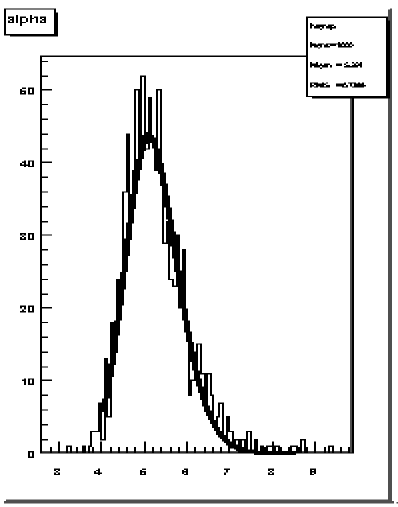
P incomplete gamma function

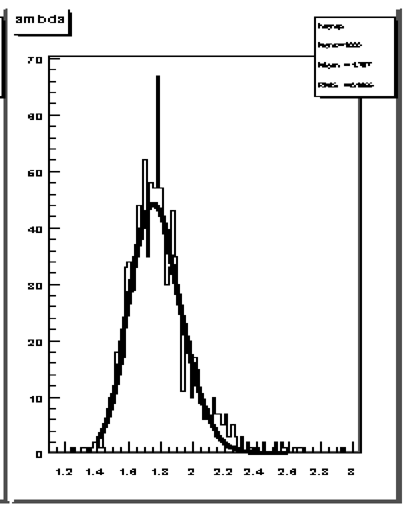
Shower fluctuations

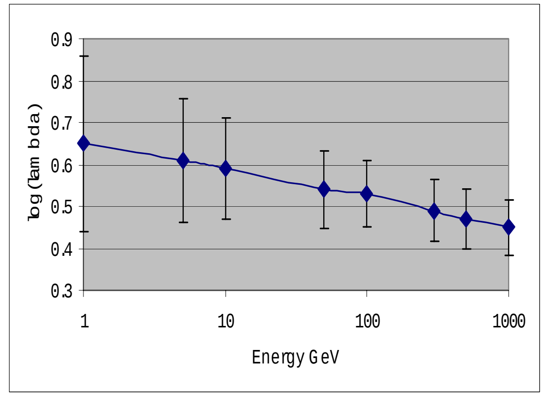
Fluctuations in energy deposition come from fluctuations of parameters

α and λ log-normally distributed.

Mode and width dependent on incident energy

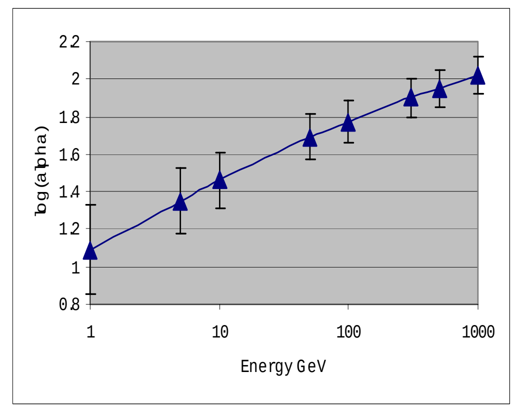






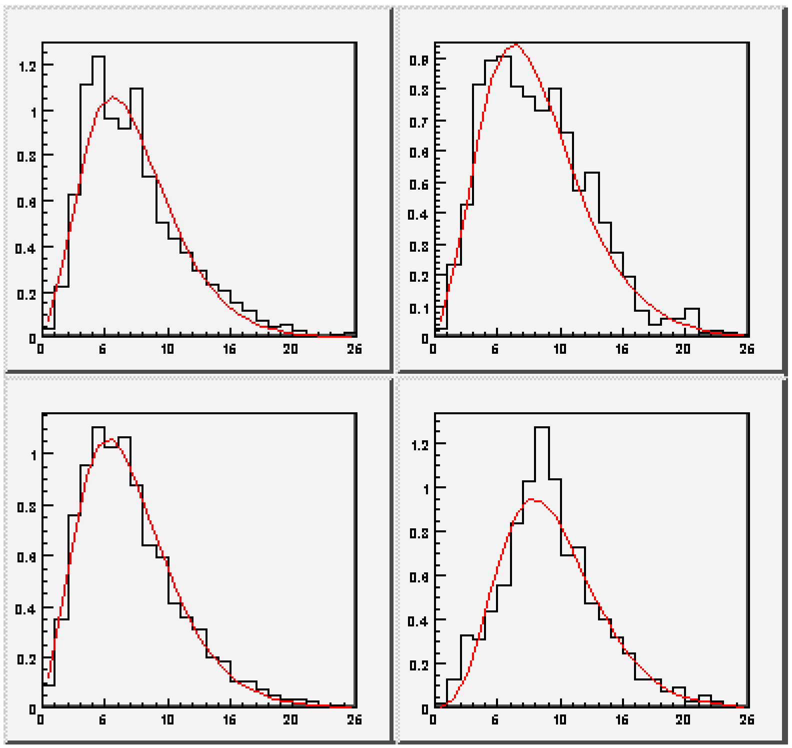
$$\lambda = 2.29E^{-0.031}$$

$$\alpha = 2.65E^{0.15}$$

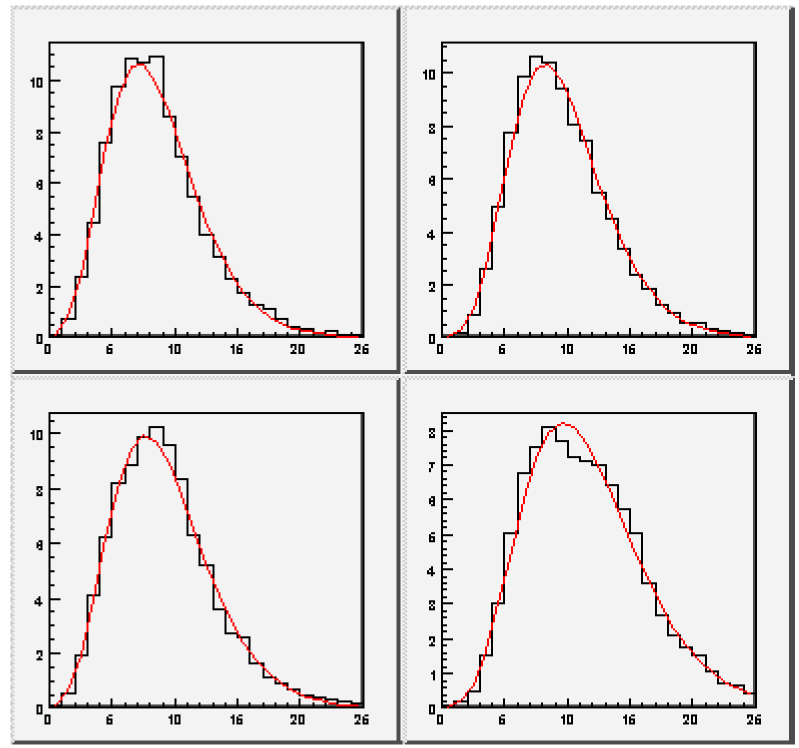


Shower fluctuations -

10 GeV electrons on 25X0 CsI calorimeter



100 GeV electrons on 25X0 CsI calorimeter



Shower Profile Fitting

METHOD:

Fit the energy distribution to the MEAN longitudinal profile

Function to minimise:

$$\chi^2 = \sum_{i<8} \frac{(E_i - \overline{E}_i)^2}{\sigma_i^2}$$

with

$$E_i = E_0 \int_{z_i+z_0}^{z_{i+1}+z_0} f_L(z)dz$$

Parameters:

- α, λ shower parameters defining the global shape
- E_0 incident energy
- z_0 starting point of the shower

E_0 and z_0 are free parameters.

Take the mode value of α, λ at energy E_0

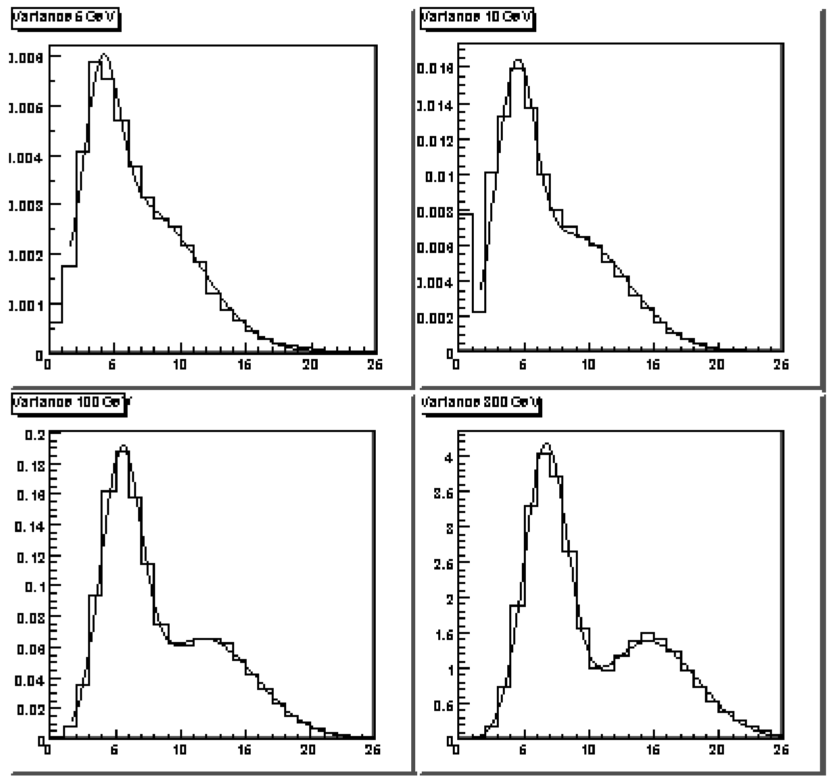
Shower Profile Fitting - errors?

ERROR EVALUATION:

1- Simple $\sigma_i^2 = E_i$

2- MC value: variance is a function of depth and incident energy:

$$\sigma^2(z) = f(E_0, z)$$

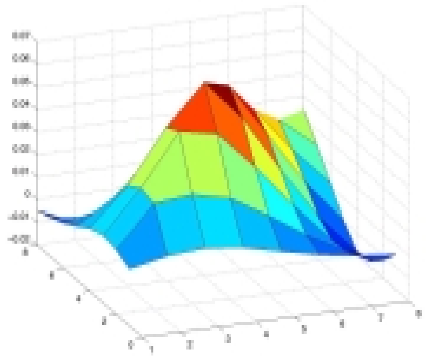


3- Take into account layer to layer correlations: covariance matrix

$$\chi^2 = \sum_{i,j<8} (E_i - \overline{E}_i) V_{ij} (E_j - \overline{E}_j)$$

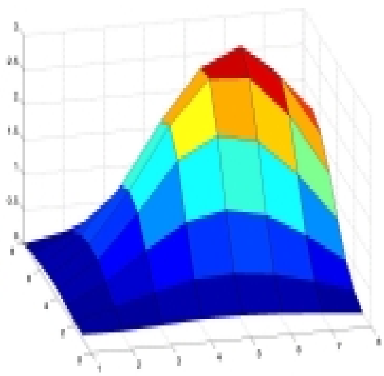
Shower Profile - errors

Covariance matrix:



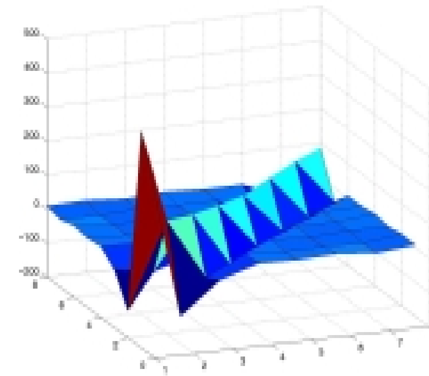
10 GeV

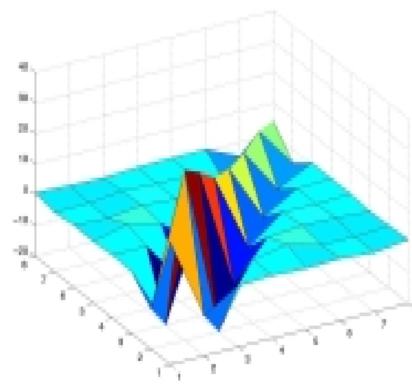
100 GeV



Inverse of covariance matrix:

10 GeV





100 GeV

Shower Profile Fitting - Comparison

- Small differences:

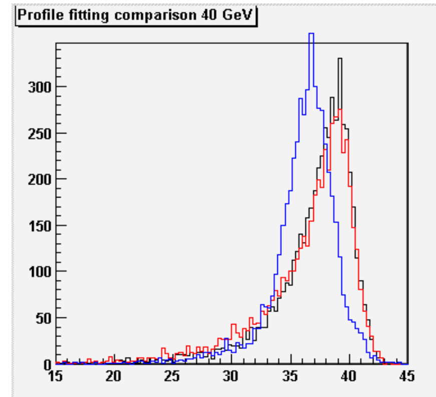
 - covariance matrix yields a more symmetrical distribution but under-evaluates the mode.

 - simple errors yield longer tails than fitted errors

1 Simple errors

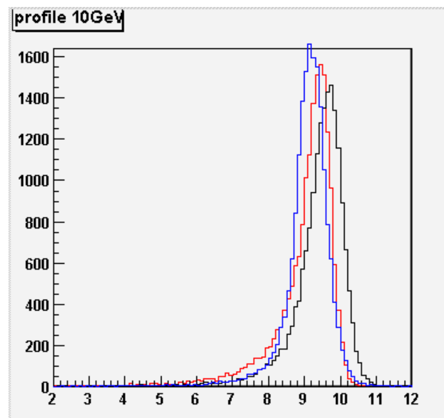
2 fitted errors

3 covariance matrix



- Drawback:

 - Having an analytical expression for the covariance matrix!



40 and 10 GeV positrons with TBSim

- We will use hereafter the simple expression of errors

Shower Profile Fitting

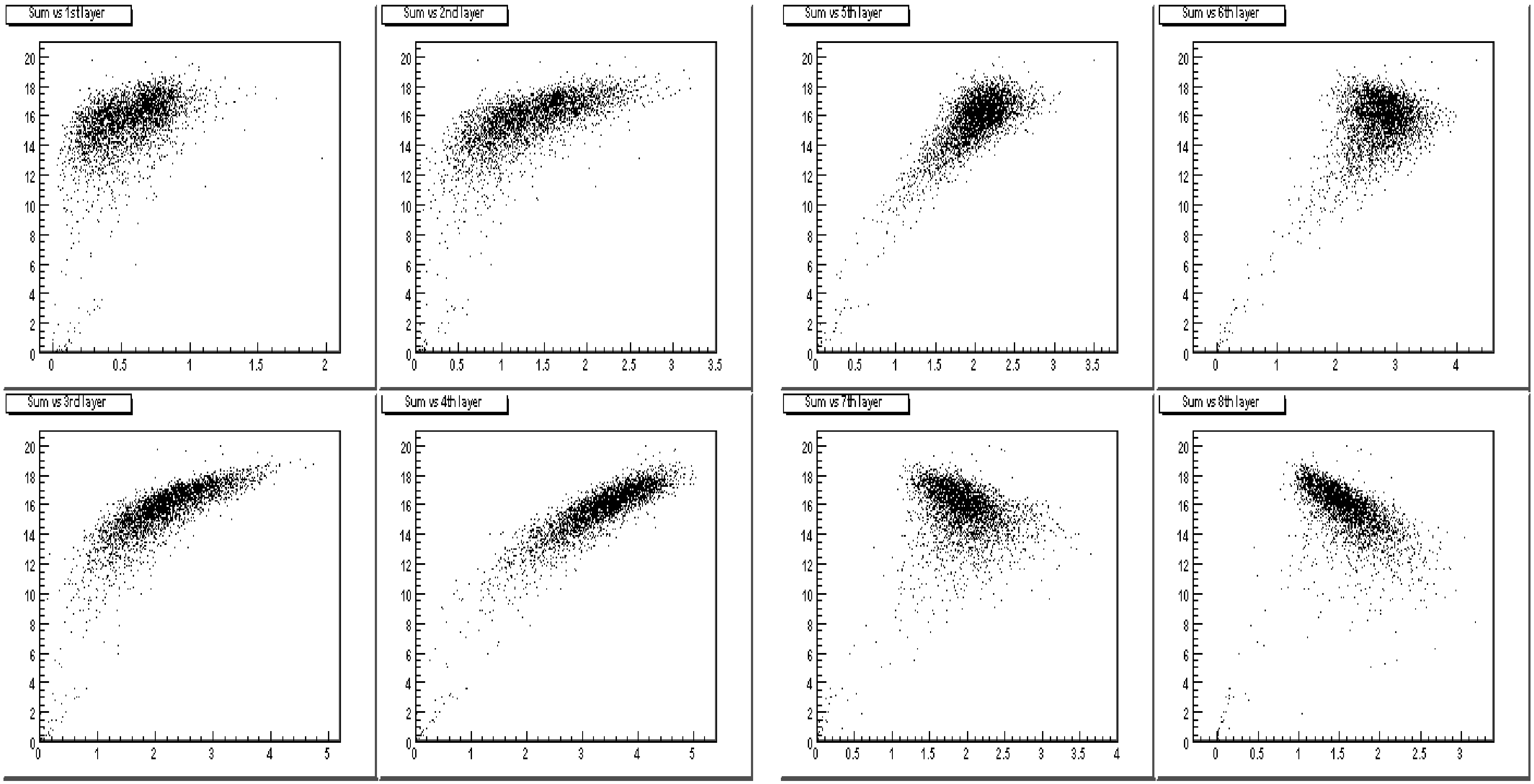
GOOD POINTS:

- Better estimation of incident energy
- Does not broaden energy distribution (at least when shower max is contained)
- Works from ~ 10 GeV up to several hundreds of GeV

DRAWBACKS:

- Larger tails in the distribution
- Needs a special form to handle large incidence angles
- Difficulty to handle fluctuations properly:
  - Comparing to the mean profile is not correct.
  - Starting point parameter is here to compensate this

Correlations: total energy - energy per layer



Energy correction using last layer

METHOD:

- Linear fit of the distribution Esum - Elast at several energies using MC data

$$Esum = a\ Elast + b$$

- Fit energy dependency of *a*.

  Found with TBSIM:

$$a = 1.111 + 0.557 * E$$

- Then the estimator of the energy is

$$Ecorr = a(Esum)\ Elast + Esum$$

- Iterate

- Can do the same at several angles

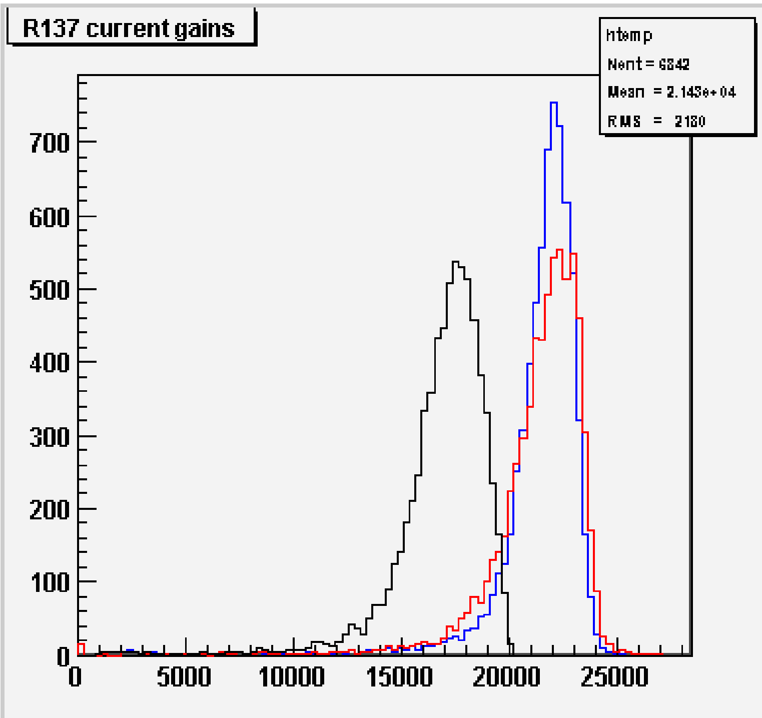
POSITIVE POINTS:

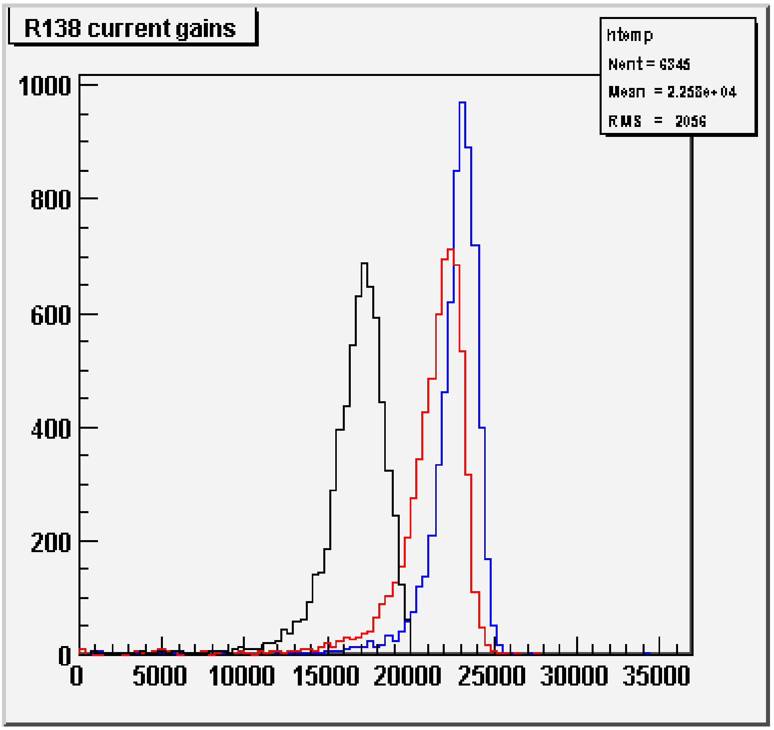
- Simple and robust algorithm
- No tails enhancement
- Efficient : gives very good energy resolution
- Works at any angle

DRAWBACK:

- Does not work if shower max is not contained : correlation is different

Performances - Beam Test





sum	7%	sum	7.2%
profile fitting	5.3%	profile fitting	4.8%
correlation	3.9%	correlation	3.8%

IMPLEMENTATION

GlastSim:

- Shower Profile implemented in CalProfile inheriting from Recon.
- Called after CAL and TKR Recon
- Uses Midnight package : C++ translation of CERNLIB Minuit (R. Brun, G. Barrand). Same commands : MIGRAD, FCN …
- Uses incomplete gamma function

TbRecon:

- Shower Profile and correlation method implemented in CalClustersAlg.cpp
- Called before TKR Recon (no information from TKR)
- idem
- idem
- Some information from tracker is needed to improve efficiency

Algorithms Comparison

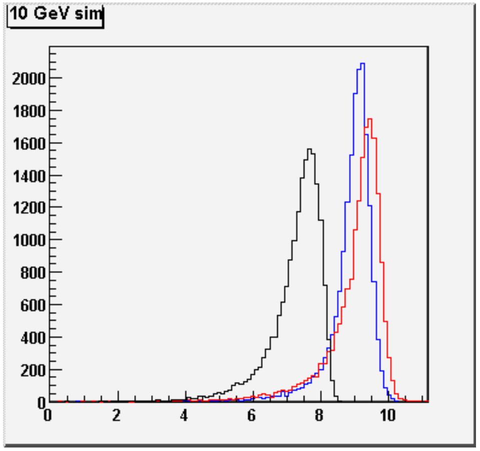
Situation :

- when shower max is contained correction with last layer :

  - sharper distribution
  - more robust
  - easy to implement even at large angles

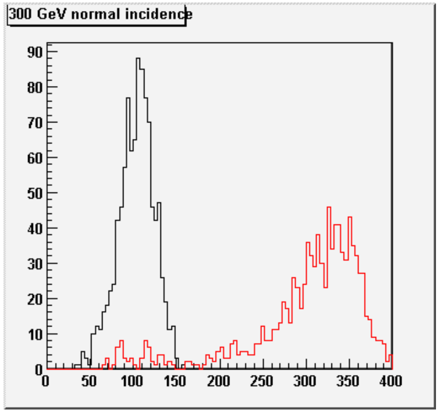
10 GeV positrons

TBSIM



- when shower max is not contained :

  only solution is profile fitting : larger distribution but better energy estimate



300 GeV

G3.21 simulation

resolution

19% raw

12% fit

Which reconstruction for which type of event?

- Algorithm used strongly dependent of position of shower maximum in the calorimeter.

- At high energies on axis shower max is not contained :use profile fitting

- At intermediate energies and/or large incidence angle: use last layer correlation